

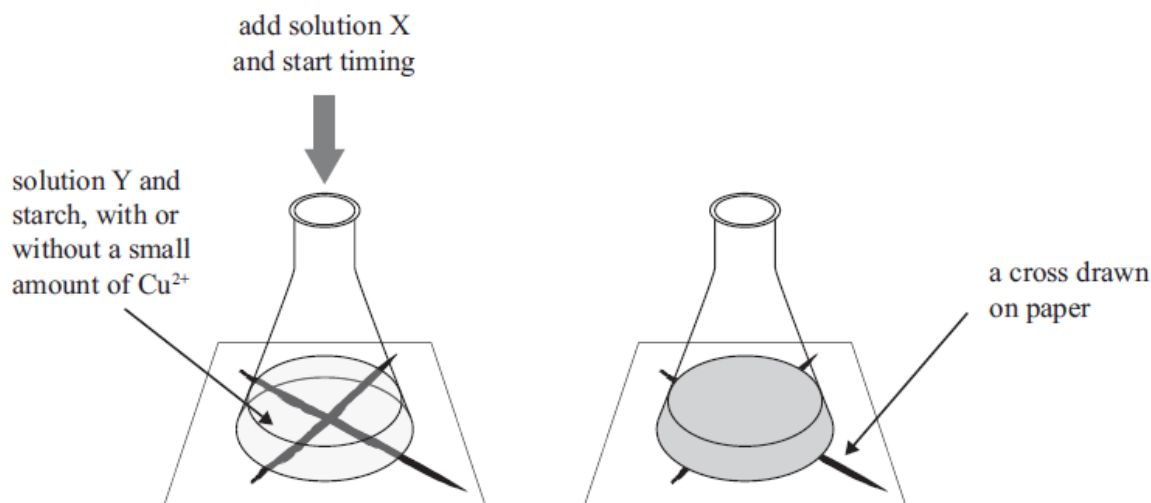
Rate of reactions

1) a) Hydrochloric acid was reacted with calcium carbonate in the form of marble chips (lumps) and powder (crushed marble chips) in an experiment to investigate factors affecting the rate of a chemical reaction.

(i) Identify the factor being investigated.

(ii) Explain why the hydrochloric acid would react faster with the powder.

b) A *clock reaction* involves mixing solution X and solution Y with starch present. When the reaction is complete the solution turns blue-black in colour. A student carried out this reaction between solution X and solution Y in a conical flask. Over time, the cross on the piece of paper under the flask disappeared when viewed from above.



The following experiments were carried out, and the times taken for the cross to disappear recorded.

Experiment		Temperature/ °C	Time for cross to disappear/s
1	No Cu ²⁺ present	25	42
2	No Cu ²⁺ present	50	23
3	Cu ²⁺ present	25	5

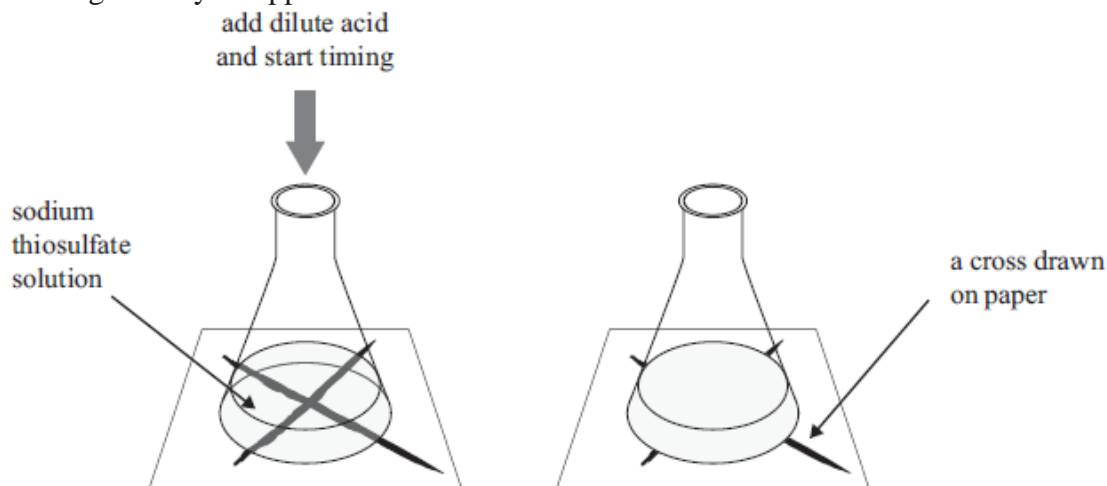
Elaborate on why the reactions in **Experiment 2** and **Experiment 3** occur faster than the reaction in **Experiment 1**. In your answer, include the following words or terms.

collisions activation energy temperature effective catalyst

2) When dilute hydrochloric acid, $\text{HCl}(aq)$, is added to sodium thiosulfate, $\text{Na}_2\text{S}_2\text{O}_3(aq)$, in a conical flask, the following reaction occurs:



A pale yellow solid of sulfur, $\text{S}(s)$, forms during the reaction. Over time, a cross on a piece of paper under the conical flask gradually disappears when viewed from above.



(a) List TWO ways that the rate of this reaction could be decreased.

(b) The following experiments were carried out, and the times taken for the cross to disappear recorded. The $\text{HCl}(aq)$ was in excess in all of the experiments.

Experiment	Concentration of 50.0 mL $\text{Na}_2\text{S}_2\text{O}_3$ / mol L^{-1}	Concentration of 10.0 mL HCl / mol L^{-1}	Temperature / $^{\circ}\text{C}$	Time taken for cross to disappear/s
1	0.0500	1.00	25	127
2	0.0250	1.00	25	206
3	0.0500	1.00	45	34

Analyse how the results of **Experiment 2** and **Experiment 3** compare to **Experiment 1**.

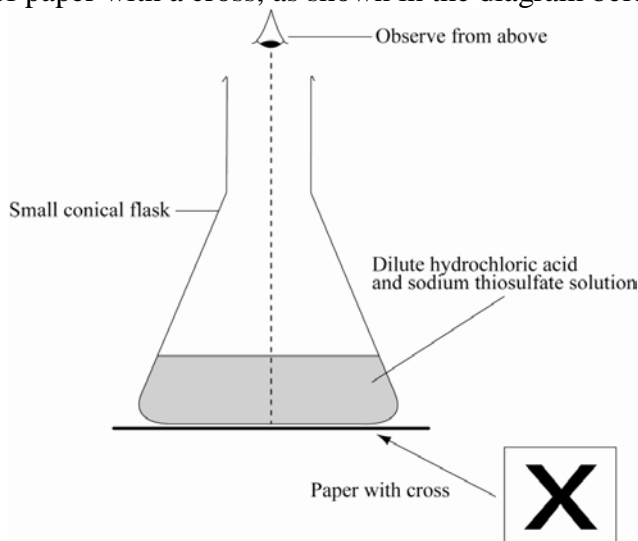
In your answer you should:

- identify the factor being changed and the effect it has on the reaction rate
- explain how the rate of reaction was affected, with reference to the collision of particles, and activation energy where appropriate.

Experiment 2 compared to **Experiment 1**:

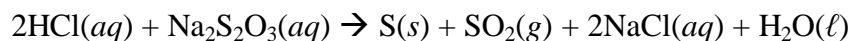
Experiment 3 compared to **Experiment 1**:

3) The reaction between hydrochloric acid solution and sodium thiosulfate solution produces a precipitate of sulfur that makes the resulting solution go cloudy. The reaction is carried out in a conical flask, which has been placed on a piece of paper with a cross, as shown in the diagram below.



The rate of this reaction can be measured by timing how long it takes for the solution to go so cloudy that the cross can no longer be seen through the solution.

The equation for this reaction is represented by:



a) how the rate of this reaction would change if the reaction was repeated:

i) with a more diluted solution of sodium thiosulfate.

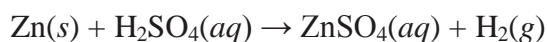
ii) at a lower temperature.

b) Explain how decreasing the concentration of sodium thiosulfate and decreasing the temperature of the reactants affects the reaction rate. In your answer, you should refer to:

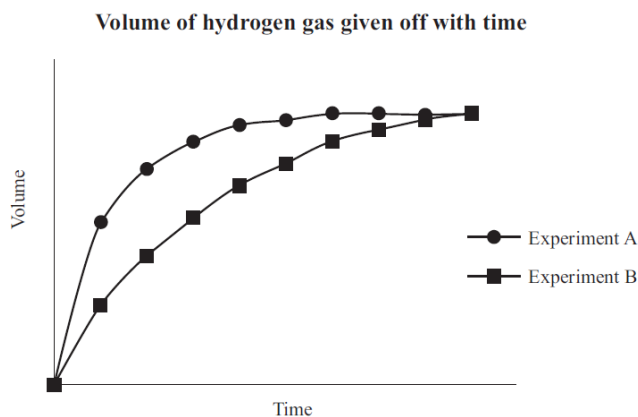
particle collision

the reaction between hydrochloric acid and sodium thiosulfate.

4) a) Zinc foil reacts with dilute sulfuric acid to produce zinc sulfate and hydrogen gas.



Two experiments were carried out using the same mass of zinc foil and excess sulfuric acid of concentrations 0.500 mol L^{-1} and 1.00 mol L^{-1} . The reactions were carried out at 25°C . A graph showing the results of the two experiments is shown below.



i) Circle the letter of the experiment which was carried out using the 1.00 mol L^{-1} sulfuric acid. Justify your answer in terms of the collision of particles.

ii) **Experiment A** was repeated, using the same mass of zinc granules instead of zinc foil.

The rate of reaction increased.

Explain this effect on the reaction rate, in terms of the factor investigated and the collision of particles.

iii) **Experiment A** was repeated again; this time the reaction was carried out at a temperature of 15°C . Discuss the effect of this temperature change.

Your answer must include reference to:

- reaction rate
- collision of particles

5) An experiment to investigate the rate of reaction between a 5 cm strip of magnesium ribbon and 20 mL of 1.00 mol L⁻¹ hydrochloric acid was carried out at 25°C. The hydrochloric acid was in excess. The experiment was repeated under different conditions as given below.

Complete the table below for EACH change, by:

- stating the factor being investigated
- describing how the reaction rate would be affected by using the word '**increase**' or '**decrease**' in your answer.

		Factor being investigated	Effect on reaction rate
Change One	The magnesium ribbon was added to a mixture containing 10 mL of 1.00 mol L ⁻¹ hydrochloric acid and 10 mL of water.		
Change Two	The reaction was carried out at 40°C.		
Change Three	One side of the strip of magnesium ribbon was coated with nail varnish. This made one surface of the magnesium ribbon unreactive. The magnesium ribbon was then added to the 1.00 mol L ⁻¹ hydrochloric acid.		

Discuss the effect on the reaction rate for **Change One** above, in terms of the factor investigated and the collision of particles.

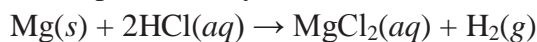
6) An experiment was carried out by reacting calcium carbonate with dilute hydrochloric acid. The equation for this reaction can be represented by:



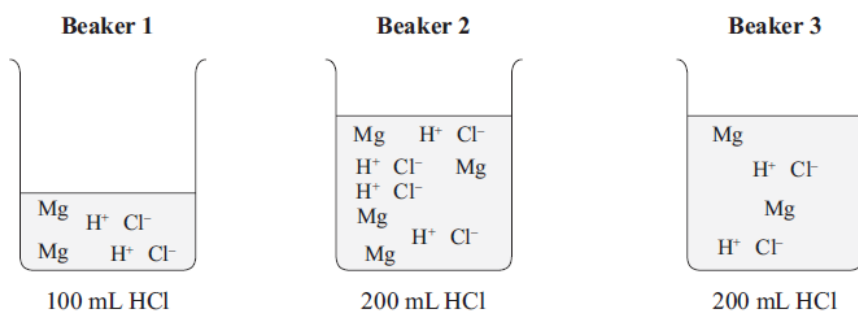
State THREE ways to increase the rate of this reaction.

Three experiments were carried out by reacting magnesium metal with hydrochloric acid.

The equation for this reaction can be represented by:



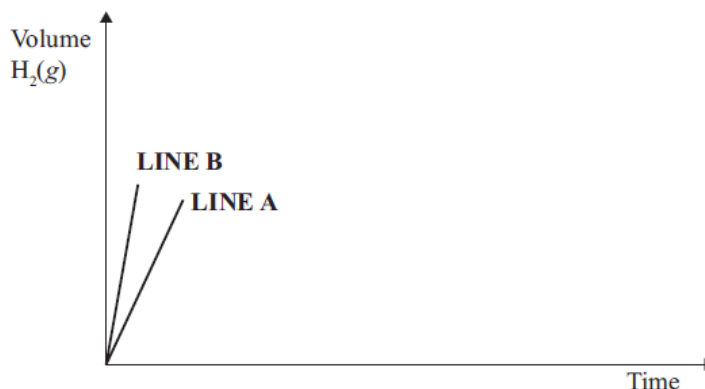
The beakers drawn below show particle representations of magnesium metal and hydrochloric acid just before the reaction is about to begin.



Mg = particles of magnesium metal

H⁺ Cl⁻ = particles of hydrochloric acid

The rate of reaction can be followed by recording the volume of hydrogen, H₂, produced. The graph below shows the volume of hydrogen produced during the **initial** part of the reaction.



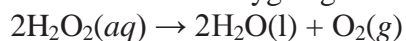
Which beaker(s) corresponds to:

LINE A of the graph **LINE B** of the graph

Explain your answers in terms of

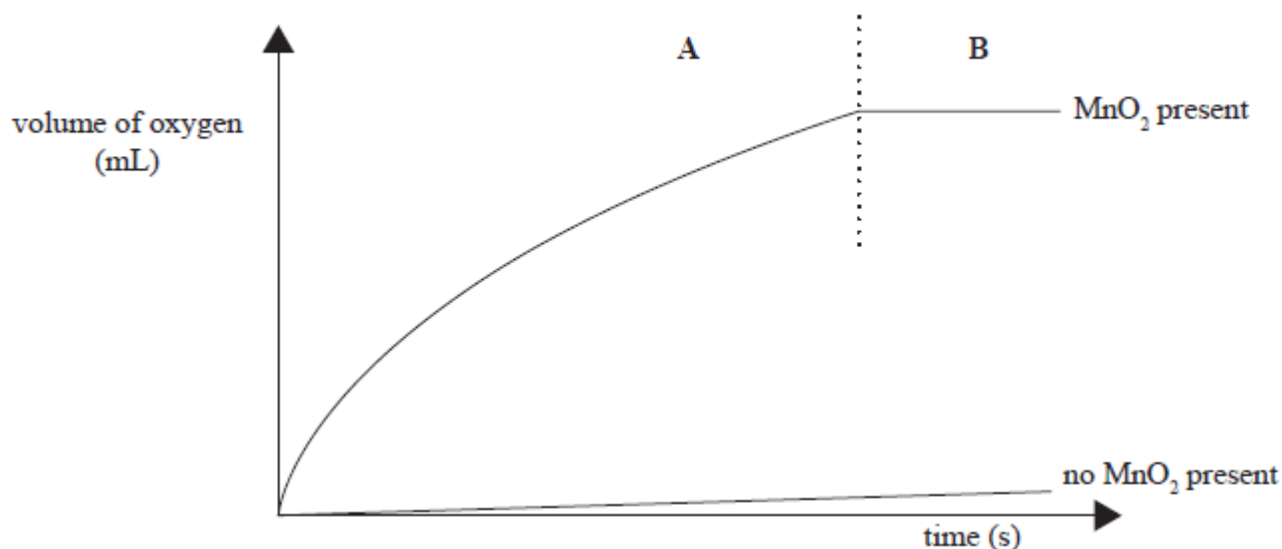
- particle collision
- concentration of the particles present.

7) Hydrogen peroxide decomposes to form water and oxygen gas.



The rate of decomposition is changed with the addition of manganese dioxide, MnO_2 .

The rate of the reaction can be followed by recording the volume of oxygen produced. The graph below shows the volume of oxygen produced with, and without, manganese dioxide.



(a) Describe what happens to the rate of decomposition of hydrogen peroxide when manganese dioxide is added.

(b) A student suggested that manganese dioxide is a catalyst for the decomposition reaction. Explain the role of a catalyst in changing the rate of a reaction.

Your answer must include reference to:

- particle collision
- Activation Energy.

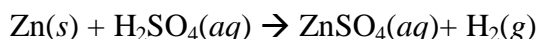
(c) One line on the graph on the opposite page is divided into two time periods, A and B.

Discuss the change in reaction rate in terms of particle collisions during these two time periods, A and B.

Time period A:

Time period B:

8) An experiment was carried out by reacting zinc metal with excess dilute sulfuric acid. All the zinc was used up in the reaction. The equation for this reaction is shown below.



(a) The experiment was repeated, but this time 2 mL water was also added to the beaker. Again the zinc was all used up. Explain why: when water is added, the rate of reaction will decrease.

(b) Small pieces of copper can act as a **catalyst** for the **reaction** between zinc and dilute sulfuric acid. Discuss how this claim could be tested by experiment.

9) In an experiment, a sample of large marble chips (CaCO_3) is added to 200 mL of dilute hydrochloric acid in an open conical flask. The reaction that occurs is shown below.



As the carbon dioxide gas escapes from the flask, the total mass of the flask and contents decreases. The loss in mass is recorded at 5 minute intervals until the reaction has stopped. The experiment is repeated, using the same mass, but different sized, marble chips. The results are shown in the table below.

Time (minutes)	Mass loss of flask and contents/g		
	Large marble chips	Medium marble chips	Small marble chips
0	0.00	0.00	0.00
5	3.29	3.73	3.98
10	3.88	4.00	4.00
15	4.00	4.00	4.00

- (a) What factor affecting reaction rate is being investigated in this experiment?
- (b) What conclusion can be made about the reaction rate using the data in the table?
- (c) Explain the change in reaction rate that occurs, with reference to the collisions of particles.

10) Hydrogen peroxide decomposes at room temperature (25°C) according to the following equation.



As the decomposition reaction occurs, bubbles of gas are produced.

- (a)** On addition of a very small amount of solid manganese dioxide, the rate at which the bubbles of gas are produced is increased so that rapid fizzing is observed. Further observation indicates that manganese dioxide remains after reaction has stopped.

With reference to the collisions of particles, explain why the reaction rate has increased.

- (b)** Hydrogen peroxide is stored at a low temperature. Discuss this statement in terms of reaction rate.

11) The reaction between 20.0 mL of 0.500 mol L⁻¹ hydrochloric acid and 20.0 mL of 0.250 mol L⁻¹ sodium thiosulfate solution at room temperature (25°C) produces a precipitate of sulfur that makes the solution go cloudy after about 5 minutes.

- (a)** How would the **time taken** for the solution to go cloudy be affected if the reaction were carried out in a water bath at a temperature of 50°C?
- (b)** With reference to the collisions of particles, explain why the reaction is affected in this way.